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GLACIAL FEATURES OF THE ALASKAN COAST BETWEEN YAKUTAT BAY AND THE ALSEK RIVER[1]

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Since the pioneer studies of Russell, Reid, and Muir among the glaciers of southern Alaska, the extension of exploration has gradually brought more and more of them within the range of observation, until now most of the more important have been located and a few of them carefully described. The ice-fields of the St. Elias region are among the most interesting of these, and, thanks to the researches of Russell, Gilbert, Tarr, and Martin, are among the best known. It was my privilege in 1906 to explore portions of the coast immediately east of the field studied by these men. The present paper is presented in order to record for the first time[2] the glacial features of that strip, and to form the basis for the further exploration and comparative study which is sure to come in later years.

From Yakutat Bay to the Alsek River the outer coastal mountains, for which I propose the name Brabazon Range,[3] is separated from the

[1] Published by permission of the Director of the U. S. Geological Survey.

The accompanying map has been redrawn and adapted from the field map prepared in 1906 by my associate in the field, Mr. A. G. Maddren. Certain additions are based on photographs and surveys by Mr. A. J. Brabazon, of the Canadian Boundary Survey.

[2] Previous maps show the position of the larger glaciers, but no description of them has been given.

[3] From A. J. Brabazon, of the Canadian Boundary Survey, who in 1895 made the first topographic map of these mountains. The range begins at the lowest

Pacific by an alluvial coastal plain. On the east side of Yakutat Bay low morainic deposits, densely wooded, slightly relieve the general flatness, and along the mountain front low rocky knobs rise to a height of 100 feet or more. Aside from these exceptions, the plain has the monotony of a delta surface. Much of it is covered with dense spruce forests; but wide tracts are kept bare by the floods[1] of such rivers as the Dangerous and the Alsek, and by the tides, as at the mouth of the Italio; while swamps and wet mossy prairies occupy large irregular areas farther inland.

The Brabazon Range is low as compared with the lofty peaks west of it; but nevertheless it is a notable feature of the coast. It has a steep seaward front, which, although somewhat irregular in outline, plunges abruptly beneath the alluvial flat without extensive foot-hills or projecting spurs. One depression interrupts the continuity of the ridge in the area discussed—the open channel of the Yakutat Glacier. The highest peaks of this range are Mount Unana (6,000 feet) and Mount Ruhamah (5,600 feet[2]) on the east side of Russell Fiord, together with Mount Reaburn[3] (5,300 feet) and its nameless neighbors east of the Yakutat Glacier. Within the mountains the topography is buried under a thick mantle of ice, through which isolated mountains protrude—"a land of nunataks," as Russell has aptly described the country about Mount Logan.

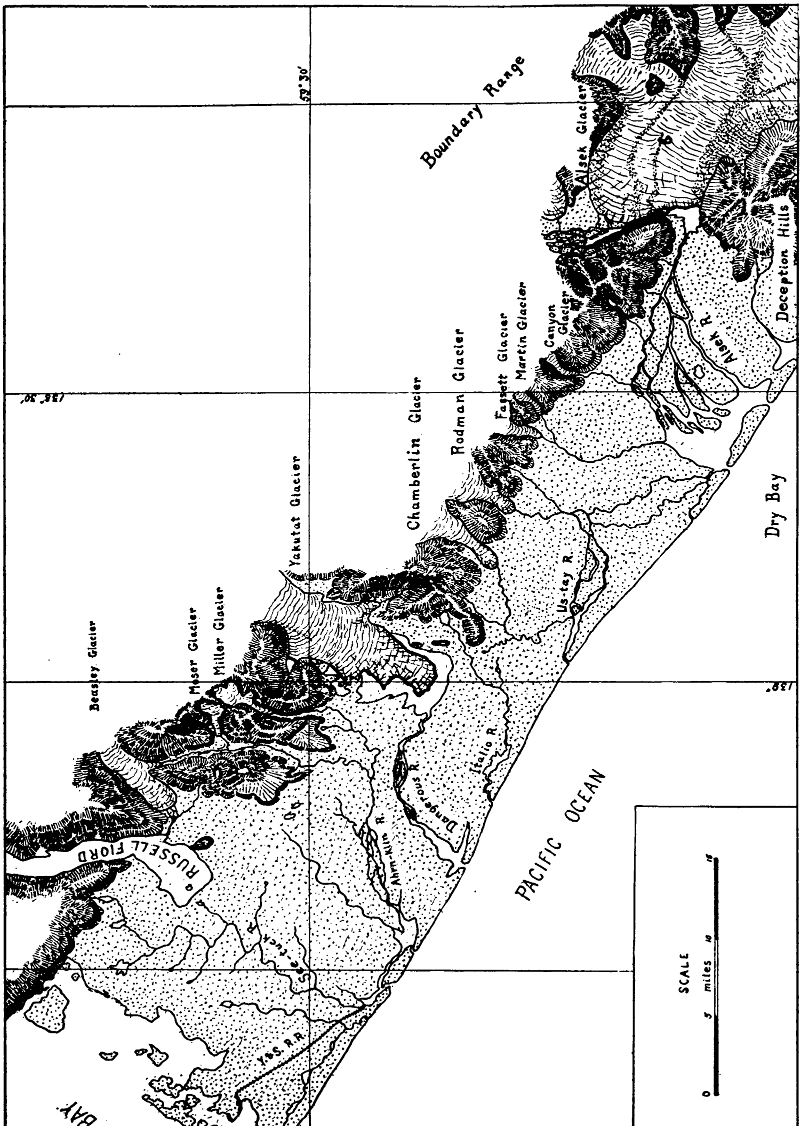
The only large river of the region is the Alsek—a powerful stream which rises in the plateau north of the mountainous belt and trenches the uplift in a series of wild canyons which have a total length of

canyon of the Alsek River and fronts the foreland northwest as far as Russell Fiord. It is separated from the inner ranges largely and perhaps wholly by broad ice-fields. Structurally it seems to be continuous with the Puget peninsula on the northwest and Deception Hills on the southeast, but it is separated from them by the fiord and river mentioned.

[1] For an example of similar devastation by the Yatse River, see Russell "Second Expedition to Mt. St. Elias," U. S. Geological Survey, *Annual Report*, *XIII*, p. 60.

[2] Elevations taken from maps of the Canada-Alaska Boundary Award (based on Brabazon's survey of 1895).

[3] This peak is named in honor of Mr. W. B. Reaburn, who, as a member of the U.S. Boundary Survey Party in 1906, was the first white man to cross the Yakutat Glacier, from the surface of which this peak is a conspicuous landmark. The mountain is situated approximately in latitude 59° 26½′ north and longitude 138° 38½′ west, and is the first high peak east of the Yakutat Glacier. (See Fig. 3.)



Map of Alaskan coast between Yakutat Bay and the Alsek River The dotted area is the coastal plain; the larger glaciers are shown by the broken lines, with moraines dotted, while the little cliff-glaciers are represented by the black.

about 110 miles. Majestic glaciers descend into it at several points on either side, contributing their load of detritus to its turbid current. Eventually it emerges from its canyon through the outermost or Brabazon range and spreads out in shifting channels over a broad, gravelly delta. At the time of our visit there were three main distributaries at the head of the delta, which anastomose with each other to some extent below. An abandoned moraine of the Alsek Glacier checks the river temporarily as it leaves the canyon, and thus forms a small but deep lake at the elbow of the sharp bend. Icebergs of all sizes are constantly breaking off from the end of the glacier. Some lie stranded on the shelving shores of the lake, while others gradually drift into the current of the outlet and are thence whirled out upon the delta. All melt before reaching the Pacific.

The coastal mountains of this part of Alaska are still, like Greenland, in their glacial period. All the principal valleys are clogged with ice, and only the smaller gulches are without glaciers. The glaciers vary in size from mere snow-fields which have a slight motion, to great plateaus of ice, scores of square miles in extent. The front of the Brabazon Range affords eight or nine glaciers of considerable size, in addition to the Alsek Glacier which lies to the west, and the numerous little cliff-glaciers which are found in the lateral ravines. Some of these larger lobes we observed only from a distance, but others were examined in some detail.

We may now take up the consideration of the several glaciers individually, beginning where Russell and his successors left the work, and carrying the chain with varying detail as far as the Alsek. The first in order is the Beasley Glacier,[1] a lobe which joins the sources of the Hidden Glacier across a snow-filled pass and thence descends southwestward on the east side of Russell Fiord. This we saw only from the mountain spur east of it. Its clear white surface is striped with two or more distinct moraines. Sloping gradually downward, it ends in a barren outwash-flat composed of gravel and bowlders.

[1] This glacier is generally known to the people of Yakutat as the "Fourth Glacier," but as there is no logical starting-point in enumerating the glaciers by number in such a way as to make this the fourth, it seems advisable to give this large and conspicuous lobe a definite name. For this reason, it is proposed to call it the "Beasley Glacier," in recognition of the valuable services which have been rendered to every explorer, who has visited the Yakutat region since the eighties, by Mr. R. W. Beasley, of Yakutat.

Fig. 1.—Terminus of the Moser Glacier, with snow-bank glaciers upon the slopes behind. Taken from the crest of the moraine.

The water discharged issues in several streams, but these combine in a recent cut through the encircling morainic ridge and reach the fiord as a single river.

The Moser valley contains two considerable tongues of ice and several little cliff-glaciers. At the extreme head of the valley a short triangular lobe overflows from the adjacent Beasley Glacier, while a somewhat larger glacier occupies the tributary canyon which joins the main valley from the eastward. The latter we take to be the Moser Glacier.[1]

The triangular lobe from the Beasley Glacier is smooth and white. At its terminus there is no distinct moraine, nor is there any considerable amount of débris upon the end of the ice itself. A level outwash train of coarse gravel trends away from the glacier down the valley.

The Moser is an excellent example of the small alpine glacier. If its snow-fields are included, it is about $2\frac{1}{2}$ miles long, the bare icy portion being about $1\frac{1}{2}$ miles in length. The width of the cirque is nearly $1\frac{1}{2}$ miles, but the glacier itself has a constant width of slightly less than half a mile. It lies in a deep canyon, the walls of which rise steeply to heights of 1,500–2,000 feet, and then more gently to summits about 2,000 feet higher. The cirque is filled with snow and névé which is slightly crevassed. Lower down the transverse crevasses become much more numerous and the clear ice makes its appearance. About a mile from the lower end, the angle of slope becomes much gentler, the crevasses less numerous and radial rather than transverse in direction, and the surface is comparatively smooth. At the time of our visit it was not difficult to cross the lower part of the glacier in almost any direction, provided one paid due regard to the many, although narrow, cracks. On each side of the lower end of the tongue the ice is covered with débris which stands out upon the surface in relief, forming two lateral moraines. A medial moraine makes its appearance suddenly three-tenths of a mile from the end, and is a prominent feature of the nose of the glacier. Its origin is not obvious. At no distant time the Moser Glacier has been three-

[1] Lieutenant Hugh Rodman, of the U. S. Fish Commission, passing along the front of the foreland in 1901, observed that this valley contained a glacier, and, supposing doubtless that it was a single tongue of ice, he named it the Moser Glacier. In 1906 we found two distinct glaciers in this valley, and have applied to the larger of them the name proposed by Lieutenant Rodman.

tenths of a mile longer than at present, and simultaneously probably several hundred feet thicker. This expansion is clearly recorded by a bowldery moraine which encircles the mouth of the canyon and is attached to the rocky walls on either side by a gradually diminishing lateral moraine, or moraine-terrace, which now stands at a considerable elevation above the glacier. The abandoned space inside the moraine is a bowldery waste devoid of vegetation. The outer part of the moraine itself, however, is forested with spruce, and its hummocky topography is thereby obscured.

The little cliff-glaciers of this valley which have been mentioned are of various sizes and are about four in number. Three of these occupy the southern slope of Crescent Mountain.[1] They are steep, cascading glaciers which are plastered in the heads of the shallow gulches. The fourth, which lies upon a gentler slope south of the Moser Glacier, is irregular and roundish in outline. It is noteworthy that no glaciers exist on the northeast slope of Slate Peak.[2]

The next valley to the eastward, drained by another branch of the Ahrn-klin River, contains one glacial lobe and several little snowbank glaciers. Its cirque affords an ample gathering ground for snow, and is separated from the head of the Moser Glacier on the west by a sharp arrete. The tongue of ice itself is somewhat longer and narrower than its neighbor, being about 2¼ miles long and about one-fourth of a mile wide. The lower end is black with moraine-stuff, and frequent avalanches from the steep walls of the canyon keep the sides dirty with similar débris.

The Miller Glacier appears to have a surface much like that of its western neighbor, but even less crevassed. It shows no evidence of recent advance and is not surrounded by a distinct moraine. Miller Creek issues from the end of the glacier and flows over a barren, gravelly valley-train out to the foreland.

The little cliff-glaciers of this canyon are few in number. We noted but one on the west side of the valley, and that at an elevation of 3,000 feet. On the east side three or four little bodies of ice occupy hollows in the lee of the mountain crest.

[1] So named from the crescent-shaped syncline of gray rock visible in its summit. It lies immediately north of the Moser Glacier.

[2] In 1906 Mr. Thomas Riggs, Jr., applied this name to the peak which separates the Beasley Glacier from the Moser valley.

The open gap which interrupts the Brabazon Range midway in its course is partially filled by the broad Yakutat Glacier. This is merely a lobe descending from the interior ice-fields, not an alpine glacier of the type illustrated by the Moser and Miller lobes. The descent of the Yakutat Glacier is gradual throughout, but at several places there are steeper declivities, more crevassed, which approach the character of ice-falls. The length of the glacier after it leaves the parent ice-field appears to be about 12 miles. Its average width is

FIG. 2.—The Miller Glacier. A short alpine glacier descending from the snows of a capacious cirque.

3–4 miles, but toward the end it becomes ragged in outline, and the width decreases to $2\frac{1}{2}$ and finally to $1\frac{1}{2}$ miles. So far as observed, the surface of the ice is badly crevassed, especially near the terminus. There the ice is broken by great cracks, some of which admit the water of the lake far back into the glacier. Four or 5 miles back from the end, and especially along the margins of the glacier, there are, however, certain stretches which are moderately smooth and may be traversed without notable difficulty. The Yakutat Glacier lacks the prominent

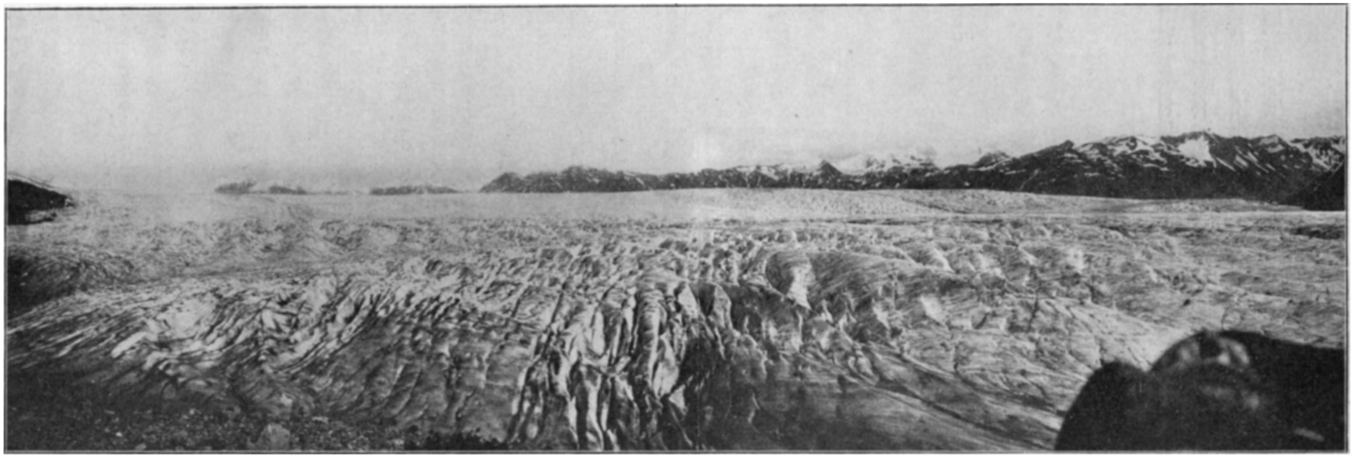


FIG. 3.—Surface of the Yakutat Glacier. On the left is the gap in the range through which the lobe finds exit from the inner ice-fields. The snowy cloud-wrapped peak to the right of the center is Mount Reaburn.

trains of débris which lie upon the surface of almost all the other glaciers of the region.

The lower end of the glacier is encircled from mountain to mountain by a crescent-shaped moraine more than a mile wide, which rises but a few score feet above the foreland. It has the characteristic knob-and-kettle topography of terminal moraines in general, contains numerous small lakes and swamps, and is strewn with bowlders. The till consists largely of rocks of the Yakutat series (early Mesozoic ?), with the addition of many crystalline schists and intrusives from the older formations. One of the most conspicuous varieties represented in the large bowlders on the moraine is the coarse graywacke-conglomerate of the upper portion of the Yakutat series.[1]

Between the inner edge of the moraine and the ragged border of the glacier lies a long, irregular lake, to which we have given the name Harlequin Lake.[2] The water is muddy with the rock-flour derived from the glacier. Occasionally during the day the crash of icebergs falling into the water may be heard, but disintegration here is much slower than it is along the front of the Alsek Glacier. The water of the lake is now discharged through a cut in the moraine and makes the Dangerous River. On the borders of the lake and the surface of the moraine there is evidence that the lake waters have recently been much higher than at present, and that they have not always used the same exit as at present. A series of well-marked and unmutilated wave-built terraces encircles the lake on the moraine side at various elevations up to 100 feet above the present surface of the water. About a mile north of the present Dangerous River the moraine is intrenched by two dry outlet channels, which converge and join before reaching the outer edge of the moraine, so that they issue in a single channel. The channels are bare and strewn with gravel and bowlders. They are from 60 to 100 feet deep, and the bottoms

[1] The outer front of the moraine is bordered by an extensive outwash-plain. Near the foothills on the west this plain slants perceptibly outward from the moraine, while nearer the Dangerous River the declivity is hardly perceptible. Shallow dry channels furrow the outwash at several places. Near the moraine the normal flood-plain of the Dangerous River is about 30 feet below the plain, but 5 miles nearer the ocean the difference is scarcely 5 feet.

[2] Named from the fact that a pair of harlequin ducks were the only living things seen upon it.

were about 40–50 feet above the surface of the lake in 1906. The fact that vegetation has not invaded these channels suggests that they are of very recent origin, and this inference is borne out by the freshness of the loose terraces bordering the lake. It is suggested that the Dangerous River outlet may at times become so clogged with icebergs as to form a dam, and that the level of the lake is therefore subject to fluctuations. This may perhaps explain the reputation for disastrous floods which the river has among the natives of the Yakutat

FIG. 4.—Shattered side-lobe of the Yakutat Glacier. Shows the scarp and the mass of freshly broken ice which resulted from the collapse in 1906.

foreland; for the breaking of such an ice-dam would liberate suddenly a large volume of water.

Tributary valleys coming in from the southeast and northwest have been obstructed by the glaciers, and thus several marginal lakelets have been produced. On the west side of the glacier we observed at least four of these blockaded lakes. The uppermost and largest one was found completely filled with a mass of clear broken ice and held in by a much-crevassed scarp of ice about 200 feet high.

Evidently the lake was formerly covered by a glacial lobe which has since collapsed. The extreme recency of the occurrence is indicated by the fact that many blocks of ice lie stranded upon the rocky sides of the valley 50–100 feet above the water, thus marking the original level of the glacier. As such detached fragments usually melt quickly in the mild summer months, it can hardly be doubted that the collapse took place in 1906. The lowest of these lakes discharges its waters into the terminal lake through a cascading brook. The higher lakes, however, must have subglacial outlets; much water is poured into them by streams from the adjacent slopes, yet there is no exit for this upon the surface. It seems probable that the subsidence of the ice in the uppermost lake was caused by an unusually rapid removal of water through such a subglacial channel.

The Yakutat Glacier receives no considerable tributaries from the mountains on either hand. A few snow-fields and a few diminutive glaciers occupy the heads of the gulches on both sides, particularly in the valley which contains the shattered ice above mentioned, but these do not reach the bottoms of the valleys.

Of the glaciers between the Yakutat and the delta of the Alsek, as well as on the west side of the Yakutat Glacier itself, I can give only brief mention. Our route lay too far from the mountains to permit us to see them in detail. The Chamberlin, Rodman, and Fassett are all large alpine glaciers, and all extend out upon the edge of the foreland. On previous maps they are represented as being lobes of the inner ice-plateau, but the view from the foreland gave no confirmation of this. Although the upper reaches of the glaciers are hidden by the turnings of their canyons, and thus it is not possible to see directly whether they come through the rock divide, it is significant that they have steep descents, which are much more characteristic of the isolated valley glaciers than of the large "through" lobes.

Two smaller glaciers lie east of the Fassett. One, the Martin[1] Glacier, is a rather narrow tongue like the Miller and descends nearly to the level of the plain. Its companion on the east is of similar size, but does not descend as low. It derives its name from the fact that it is sunk deep in a canyon, the walls of which are remarkably

[1] After Mr. E. R. Martin, who was in immediate charge of the U. S. Boundary Survey Party which surveyed this portion of the range in 1906.

FIG. 5.—The Alsek Glacier as seen from the end of the Brabazon Range. The boundary range in the rear culminates in Mount Fairweather on the right. In the left middle is the Green Nunatak with its medial moraine. The extreme left of the glacier is not shown in the picture. The canyon of the Alsek River is hidden by the spur in the foreground. (Photo by Brabazon, Canadian Boundary Survey, 1906.)

precipitous and continuous. The lower end of the glacier is smooth and dirty with the débris of avalanches from the cliffs above. Doubtless the absence of notable crevasses here is to be ascribed to the fact that the ice is closely confined down to its very end, and hence the tension which would result from an unrestrained deployment is lacking.

From the Canyon Glacier east to the Alsek River no glaciers of considerable size remain. The heads of the gulches have been glaciated, as is indicated by the well-developed cirques and the rock-bound lakes; but only very small snow-bank ice-fields now remain.

The Alsek Glacier is the largest of all in the area of our survey. It heads on the west slope of Mount Fairweather, and, after receiving many icy tributaries from the Boundary Range north of it, eventually reaches and constricts the Alsek River at its lowermost canyon. The lower part of the glacier is a great, flat ice-field or plateau having a breadth of 6–7 miles from northwest to southeast, and somewhat more from northeast to southwest. The main body of the glacier comes in from the east just behind the Deception Hills. Two broad tributary tongues enter southeast of the Green Nunatak,[1] while a third, which is double, comes down from the boundary range some distance farther to the north. Each of these tributary glaciers would in most regions be considered large by itself. The influence of the great lobe from Mount Fairweather seems at present to be slight, as is evidenced by the fact that the south side is not bulged northward at the junction. Much of the ice is clean and white, but a number of medial and lateral trains of dirt blacken it in places. Apparently by the slow spreading of the glacier itself, these moraines have widened and even coalesced in their lower courses. Different parts of the glacier show wide variations in the amount of crevassing which they have suffered. In general, the steeper parts of the tributaries are much cracked. Of the open plateau-like expanse at the end, the northern part is not much crevassed, and its level surface may be traversed safely if ordinary care is used. The cleaner part, south of the Green Nunatak and Gateway Knob, is a bristling mass of sharp seracs with deep crevasses between. It would be very difficult, and

[1] This name is applied in recognition of the fact that the medial moraine which originates in this nunatak consists chiefly of green slate fragments.

FIG. 6.—The lowest canyon of the Alsek, from within. On the left are the Alsek Glacier and the Deception Hills; on the right, the inner slope of the Brabazon Range, with four of its many little glaciers. The overloaded Alsek in the foreground is a typical glacial river. (Photo by Brabazon, Canadian Boundary Survey, 1906.)

probably impossible, to cross this portion of the glacier without going far eastward to the foot of the mountains.

On the northwest border the glacier descends gradually to the alluvium which bounds it on that side. Where the glacier reaches the river itself it has a vertical front 4 miles in length, which is interrupted only by the rock hill (called Gateway Knob) at the mouth of the canyon. To the north of this hill there appears to be little movement in the glacier, as bergs drop off only infrequently.

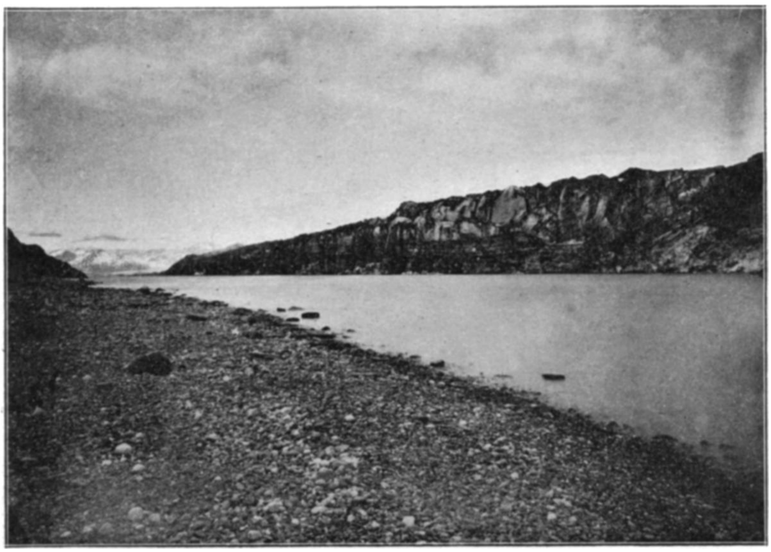


FIG. 7.—Front of the Alsek Glacier. Dirty portion north of Gateway Knob, showing the horizontal stratification of the ice.

South of the rocky knob the front shows the beautiful blue-green color characteristic of freshly broken clean ice. Large masses of ice, usually the blocks between crevasses, break off from this front with thunderous crashes on an average of more than once an hour during the summer. The front itself is nearly 200 feet high, but even these huge masses of ice disappear completely beneath the water into which they fall, and then bob up from below and float away down the river. This indicates that the depth of water along the front is very great.

From the southern end of the frontal cliff a heavy deposit of moraine extends out in the form of a broken loop. The river is actively cutting into this deposit of till and seems to have destroyed a considerable part of it. The remainder forms a hook-shaped barrier on the south side of the river and sufficiently retards the current to form the Alsek Pool. This bulb-shaped expansion of the river at the mouth of the canyon is nearly 2 miles in diameter, and but for the gravelly plain on the north would be nearly square. On the north side of the

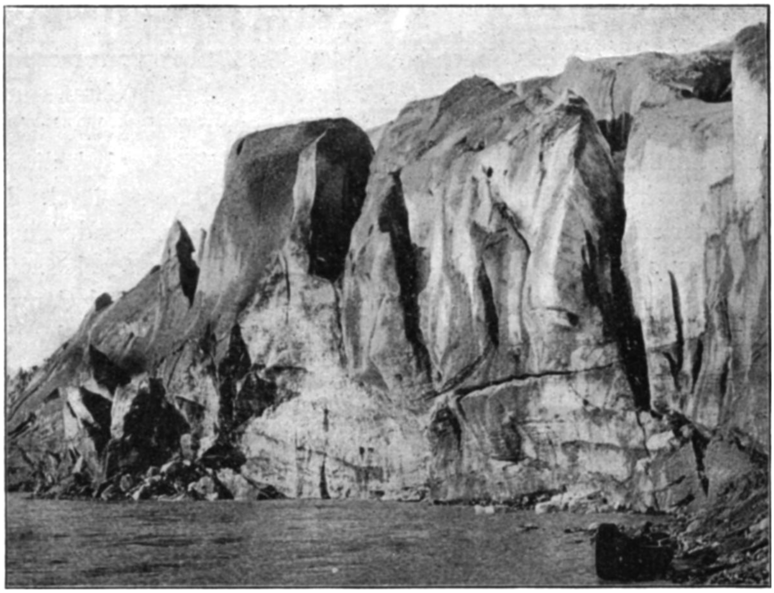


FIG. 8.—Front of the Alsek Glacier. Vertical cliff of dirty ice 160 feet high continually undermined by the river.

river the complement of the moraine ridge has not been identified. In spite of the powerful current poured into it by the Alsek the surface of this lake is nearly still. The bergs which fall from the glacial scarp drift very slowly down toward the exit from the lake. Sometimes they become stranded on the shallow north beach, where they are broken up by the waves and melt. At times those which succeed in reaching the exit congregate there in such masses that the channel becomes congested with them, and the river is temporarily

raised until sufficient force is accumulated to sweep out the obstruction. Sudden rises of as much as 6 feet, which we noted at the mouth of the canyon, are attributed to this condition.

Within the valley of the Alsek, above the lowest canyon, numerous glaciers of all sizes line the slopes on both sides. All the valleys are filled with huge lobes of ice. The smaller canyons have steep mountain glaciers, and scarcely a ravine in the higher mountains is without its little glacial tongue (Fig. 6). But this by itself is another story which is still too imperfectly known to be presented at this time.

Among the glaciers which have been described in the preceding pages we may readily distinguish four types. In the cirques and ravines high up in the mountains there are many little cliff-glaciers which are often no longer than wide, and are usually steeply inclined. The majority of them lie more than 2,500 feet above sea-level. In the larger canyons, valley-glaciers of the alpine type are found. These are tongues of ice usually several miles in length, fed by ample snows in the gathering grounds at their heads. The Miller and Canyon Glaciers are good examples. To another type, exemplified by the Yakutat and perhaps the Beasley, Tarr has applied the name "through glaciers,"[1] meaning the great lobes which protrude outward from the inner ice-plateau through gaps in the mountains. These are characteristic of the Yakutat-Alsek region, and are apparently numerous in the upper valley of the Alsek River. They are all large. The fourth type includes the great plateau-like sheets of ice which Russell has called "piedmont glaciers." They are fed by alpine glaciers from various directions and are among the largest glacial features of the region. The Alsek Glacier exemplifies this group.

One of the questions of interest with reference to all glaciers relates to their fluctuation in size. It is needless to say that, during the previous geologic epoch when all the glaciers of North America were greatly expanded, those of the Brabazon Range responded in the same way to the general causes of increase. Since that time they have retreated to fractions of their former lengths and have been reduced in thickness by 2,000 feet or less, according to their sizes and the con-

[1] Tarr and Martin, *Bulletin of the American Geographical Society*, XXXVIII (1906), p. 149.

figuration of their valleys. Changes within the past century are less well indicated.

The subject of glaciation should not be left without a statement regarding the recent changes in the glaciers. In this region no earlier measurements or surveys of sufficient accuracy have been made, and we are therefore without precise data. The fact that each of the glaciers examined is bordered at its end by a terminal moraine, which is separated from the ice itself by a barren space, indicates that the lobes have recently retreated through distances varying from one quarter of a mile to one mile. The Yakutat Glacier is bordered by a lake, and the end of the ice is so badly broken as to give one the impression that it is disintegrating in a condition of relative stagnation. It is obvious at least that none of these glaciers is now actively forwarding its lower end. In no case did we find glaciers plowing up forested moraines and showing other unmistakable signs of advance, such as Tarr reports of the Malaspina.[1] It will be a matter of much interest to watch these glaciers east of Yakutat Bay, and see if they follow the example of the St. Elias lobes, or whether they evince no sympathy with them. This will go far toward solving the question as to whether the advance of the Malaspina is due to a local cause or to some general climatic influence.

[1] R. S. Tarr, *Science*, N. S., Vol. XXV (1907), pp. 34–37.